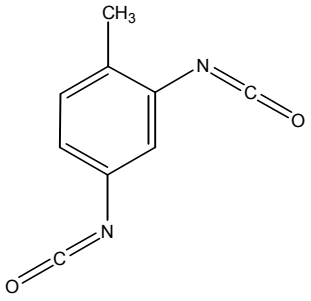
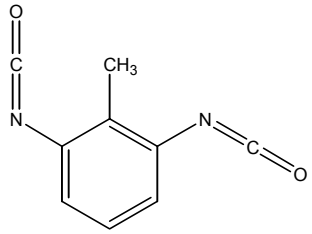
TOLUENE DIISOCYANATE
CAS No. 26471-62-5
First Listed in the *Fourth Annual Report on Carcinogens*



2,4-Toluene diisocyanate, 80%



2,6-Toluene diisocyanate, 20%

CARCINOGENICITY

Toluene diisocyanate is *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity in experimental animals (NTP 251, 1986; IARC V.39, 1986; IARC S.7, 1987). When administered by gavage in corn oil, commercial-grade toluene diisocyanate (analyzed as 85% 2,4-isomer and 15% 2,6-isomer) induced hemangiomas in the spleen and subcutaneous tissues, hepatocellular adenomas, and hemangiosarcomas in the liver, ovaries, and peritoneum in female mice; subcutaneous fibromas and fibrosarcomas and pancreatic acinar cell adenomas in male rats; and neoplastic nodules of the liver, pancreatic acinar cell adenomas, mammary gland fibroadenomas, and subcutaneous fibromas and fibrosarcomas in female rats. No treatment-related lesions were induced in male mice (NTP 251, 1986). When administered by inhalation, toluene diisocyanate (80% 2,4- and 20% 2,6-isomers) induced pathological changes in the nasal cavity and lower respiratory tract; however, no significant increase in tumor incidence was observed (IARC V.39, 1986).

There are no data available to evaluate the carcinogenicity of toluene diisocyanate in humans (IARC V.39, 1986; IARC S.7, 1987). No epidemiological data on the occurrence of cancer in workers exposed to toluene diisocyanate alone appear in the literature. One incidence of pulmonary adenocarcinoma in a 47 year old nonsmoking spray painter was described; he had also been exposed to 4,4'-methylenediphenyl diisocyanate.

PROPERTIES

Toluene diisocyanate occurs as a colorless-to-pale-yellow liquid with a sharp, pungent odor. It is sensitive to moisture and heat. It is soluble in diethyl ether, acetone, and other organic solvents, and miscible with glycol monomethyl ether, carbon tetrachloride, benzene, chlorobenzene, kerosene, and olive oil. Toluene diisocyanate may react violently with water, acids, and alcohols. Contact with bases, such as caustic soda and tertiary amines, may cause uncontrollable polymerization and the rapid evolution of heat. When heated to decomposition, it emits toxic fumes of cyanides (CN^-) and nitrogen oxides (NO_x). Toluene diisocyanate is generally available as a mixture of 2,4- and 2,6-toluene diisocyanates in ratios of 80%:20% and

65%:35%. Other mixtures are also available commercially. 2,4-Toluene diisocyanate (584-84-9) is a clear-to-pale-yellow liquid with a sharp, pungent odor. It has solubilities and reactivities similar to the mixture. It is combustible when exposed to heat or flame, and darkens when exposed to sunlight. 2,4-Toluene diisocyanate is available as a > 99.5% pure commercial product. 2,6-Toluene diisocyanate (91-08-7) also occurs as a reactive liquid. Toluene diisocyanates may break down to 2,6-diaminotoluene dihydrochloride, 2,6-diaminotoluene, and 2,4-diaminotoluene (see 2,4-Diaminotoluene, Section III.B).

USE

Toluene diisocyanate is used primarily in the synthesis of polyurethane foams. This use accounts for approximately 90% of the total supply of toluene diisocyanate. Flexible polyurethane foam is used mainly in furniture (43%) and bedding (12%); rigid polyurethane foams are used primarily in insulation. Toluene diisocyanate-based rigid polyurethane foam is used in household refrigerators and, in board or laminate form, for residential sheathing or commercial roofing. "Pour-in-place" or "spray-in" rigid foam is used as insulation for truck trailers, railroad freight cars, and cargo containers. Polyurethane-modified alkyds contain approximately 6-7% isocyanate, mostly toluene diisocyanate, and are used as floor finishes, wood finishes, and paints. Moisture-curing coatings are used as wood and concrete sealants and floor finishes. Aircraft, truck, and passenger-car coatings are often composed of toluene diisocyanate pre-polymer systems. Castable urethane elastomers are used in applications requiring strength, flexibility, and shock-absorption, and are resistant to oil, solvents, and ultraviolet radiation. They are used in adhesive and sealant compounds and in automobile parts, shoe soles, roller skate wheels, pond liners, and blood bags. They are also used in oil fields and mines. Certain elastomer products are produced from the pure 2,4-isomer rather than the 80:20 mixture (IARC V.39, 1986).

PRODUCTION

The USITC reported that an estimated 731 million pounds of an 80:20 mixture of 2,4- and 2,6-toluene diisocyanate were produced domestically in 1989 (USITC, 1990). This was a slight decrease from the 1988 total of almost 742 million lb (USITC, 1989). The Chem Sources USA directory identified two producers and four suppliers of toluene diisocyanate in 1986 (Chem Sources, 1986). U.S. production of an 80:20 mixture of 2,4- and 2,6-toluene diisocyanate increased from 616 million lb in 1985 to 665 million lb in 1986 (USITC, 1986; USITC, 1987). The United States imported 29 million lb of the compound (including mixtures) and exported 9 million lb in 1985 (USDOC Imports, 1986; USDOC Exports, 1986). In 1984, the U.S. production of toluene diisocyanate mixtures totalled 663 million lb, imports were 17 million lb, and exports were 10 million lb (USITC, 1985; USDOC Imports, 1985; USDOC Exports, 1985). In 1983, 638 million of 80:20 mixtures of 2,4- and 2,6-toluene diisocyanate were produced and over 4 million lb were imported; 44,000 lb of 2,4-toluene diisocyanate dimer and nearly 2 million lb of unmixed toluene diisocyanates were imported (USITC, 1984; USITCa, 1984). Domestic production of toluene diisocyanate mixtures totalled 591 million lb in 1982, and 556 million lb in 1981 (USITC, 1983; USITC, 1982). The 1979 TSCA Inventory reported seven U.S. companies producing 150 million lb of the isomeric mixture and one importer with no volume given; 5 companies produced 140 million lb of the 2,4-isomer; four companies produced 140 million lb of the 2,4-isomer; and four companies produced 41 million lb of the 2,6-isomer in 1977. The CBI Aggregate was 100 million to 1 billion lb for the mixture and the 2,4-isomer and

1 million to 100 million lb for the 2,6-isomer (TSCA, 1979). Toluene diisocyanate has been produced commercially since the late 1930s (IARC V.39, 1986).

EXPOSURE

The primary routes of potential human exposure to toluene diisocyanate are inhalation and dermal contact. Because of the high volatility of toluene diisocyanate, exposure can occur in all phases of its manufacture and use, and approximately 40,000 workers are potentially exposed (CHIP, 1984a). The occurrence of toluene diisocyanate in the work environment, primarily in air, has been associated with its commercial production; its handling and processing prior to urethane foam production; its release in stack exhaust from plants; and its release into the air from sprays, insulation materials, polyurethane foam, and coated fabrics. Analysis of the isomeric composition of atmospheric toluene diisocyanate in a plant producing polyurethane foam demonstrated a large increase in the level of the 2,6-isomer relative to that of the 2,4-isomer, particularly at the finishing end of the production process. Median air concentrations of 2,4-toluene diisocyanate were 5.0 and 2.3 $\mu g/m^3$ for the initial mixing and finishing ends of the process, respectively. The respective median values for the 2,6-isomer were 6.4 and 7.8 $\mu g/m^3$, with a maximum value greater than 450 $\mu g/m^3$ at the finishing end. These findings were attributed to enhanced emission of the less chemically active 2,6-isomer from the cured foam bats and retention of the 2,4-isomer as a polymer (IARC V.39, 1986). Workers having potential occupational exposure to diisocyanates include adhesive workers, insulation workers, diisocyanate resin workers, lacquer workers, organic chemical synthesizers, paint sprayers, polyurethane makers, rubber workers, ship builders, textile processors, and wire coating workers (CHIP, 1984a). Aniline and the 2,4- and 2,6-isomers of toluene diisocyanate were detected under controlled experimental conditions in the thermodegradation fumes of polyurethane varnish used in the insulation of copper wire. Consistent with these findings, the compounds were also detected in the workplace atmosphere during the industrial production of polyurethane-coated wire (IARC V.39, 1986). Exposure to unreacted toluene diisocyanate is associated with the spray application of polyurethane foam. The construction industry uses polyurethane formulations in thermal insulation, adhesives, lacquers, and paints. In most cases, the foam is applied through air spraying in confined spaces. In the United States, a typical modern housing unit of 1,800 ft^2 floor space, including furniture, carpet underlay, and bedding, contains 62 lb of flexible polyurethane foam. The transportation industry utilizes approximately 21% of flexible polyurethane foams with automobile seating and padding, resulting in the use of 5-6.5 lb polyurethane per automobile. NIOSH has determined that worker exposure to toluene diisocyanate is most likely to occur during the activities of sample collection, residue removal, spill clean-up, and equipment maintenance. Employees are required to use air-line respirators during these operations. The highest exposure levels have occurred during the spray application of polyurethane foam, a procedure which is usually conducted in confined spaces. Excursions above safe limits are a particular concern for the sprayers and their helpers. Studies summarized by NIOSH indicate that toluene diisocyanate exposure levels of 0.002-0.07 ppm have been found in the workplace, as compared with the current OSHA standard of 0.02 ppm. It appears that several household products that are commercially available to consumers may pose a risk of exposure to toluene diisocyanate if used indiscriminately. Consumers may also be exposed to toluene diisocyanate volatilized from polyurethane varnishes during the application of such coatings (CHIP, 1984a). FDA has determined that levels of toluene diisocyanate in food, food additives, or food packaging are so low that the potential daily intake is virtually nil. The Toxic Chemical Release Inventory (EPA) listed 182 industrial facilities that produced, processed, or otherwise used toluene diisocyanate in 1996 (TRI, 1990). In compliance with the Community

Right-to-Know Program, the facilities reported releases of toluene diisocyanate to the environment which were estimated to total 45666 lb.

REGULATIONS

EPA regulates toluene diisocyanate under the Clean Air Act (CAA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Resource Conservation and Recovery Act, (RCRA) and Superfund Amendments and Reauthorization Act (SARA). Under CAA, National Emission Standards for Hazardous Air Pollutants (NESHAP) addresses toluene diisocyanate emissions from production and manufacturing facilities. A reportable quantity (RQ) of 100 lb has been established for this chemical under CERCLA. Toluene diisocyanate is subject to report/recordkeeping requirements under RCRA and SARA. FDA regulates toluene diisocyanate as an indirect food additive. NIOSH recommends that exposure be reduced to the lowest feasible concentration. OSHA regulates toluene diisocyanate under the Hazard Communication Standard and as a chemical hazard in laboratories. Regulations are summarized in Volume II, Table B-142.